IB ESS IA - Further Details

Numbers correspond to items in this Outline

1. The title is descriptive and pertains to the environmental issue as a general statement of the research question (i.e., The Importance of Conservative Water Consumption Habits)..
    a. State your focused Research Question with clear and specific IV (range), DV (with units) and a CV crucial to the investigation.
    b. Final draft formatting →
        i. **Title Page:** Title, student IB candidate code [, group member(s) candidate code(s) [if applicable], session (May 20XX), word count (maximum 3 000 words), which does not include:
            1. Charts & diagrams
            2. Data tables
            3. Equations, formulae & calculations
            4. Citations/references (whether parenthetical, numbered, footnotes or endnotes)
            5. Works Cited / Bibliography
            6. Headers
        ii. **Body**: 12 point font, Arial / Times New Roman, double spaced (except Bibliography)
        iii. No need for a cover page or Table of Contents
    c. All tables, pictures, figures, charts and graphs are numbered sequentially with a short caption for description. When tables continue across a page break, relabeled column headers should appear on the new page.
        i. In data tables, cells contain only numbers (unless qualitative data) with descriptor, units, and uncertainties in column headers **only**.
    d. Mathematics, including units, should be written using an equation editor or in another proper, non-computer science, form (e.g., not m/s but rather $m \cdot s^{-1}$).
        i. Equations should be centered on their own line, with sequential numbering tabbed in parentheses on the right

$$pH = -\log_{10} ¿ \qquad (1)$$

        ii. All numbers written have proper SI units, with uncertainties expressed to the same decimal place if applicable (e.g., 3.4 ± 0.5 cm).

A. Research Question & Inquiry

2. The environmental topic/issue can be the same or similar to other students, but should be something of personal interest in either a global (e.g., plastic waste) or local (e.g., plastic brand audit at beach cleanups) one.
    a. Research must be specific and detailed to lead the investigation. Broad scopes of general concepts (e.g., fixing climate change) will not score well.
    b. Topic is appropriate to ESS and not too focused on themes from biology, economics, geography or other IB subjects, though these can be integrated into an ESS IA.

3. Develop the theoretical relationship between the variables in the RQ using known scientific concepts and/or relevant models in a focused and relevant way.
    a. Begin with a general concept or environmental issue that you will be investigating, then get more specific. Local issues are especially valued.

b. Equations, if applicable, should be derived and not just stated. This may be referenced later in the analysis and discussion section.
c. Literature reviews survey published academic sources such as journals on a specific topic, summarizing, synthesizing, and evaluating to identify key findings, debates, and gaps in research to demonstrate understanding of the subject
d. The range of, and justification for, the IV(s) is included, but not needed in the research question itself.
e. The link between the DV and the investigation is established.

4. The report **must** include literature references for the environmental topic / issue, and the strategy to address it (section B.), which explains the connections and relevance to the research question. Reliable sources in the Works Cited / Bibliography should be included in proper and recent citation methods (APA recommended, though others are fine). Data can be used from primary and secondary sources; for example, an ocean plastic clean-up strategy may be linked to a research question on surveying students about their plastic consumption.

5. Collaborative work in data collection is allowed in ESS in groups of **up to three**. In the case of group work, the Background Research, RQ and methodology must be unique for each student, which may include
    a. a different IV from anyone in the group.
    b. a different DV from anyone in the group.
    c. different data sets selected from a repository of all data collected by the group.
    d. If taking part in a large-scale activity collecting data to generate a database using standardized protocols (e.g., longitudinal, citizen science, etc.), then the investigation must be treated as a database investigation. In such a case, the methodology should be focused on the way the data is filtered and sampled from the whole database in the same way as if the data was wholly acquired from an external source.

6. Most RQ's will have one IV (with explicitly stated range in Background Research or C. Method) and one DV (with units), however
    a. derived variables may be stated as DVs (e.g., rates)
    b. two IVs may be used in comparative or correlational studies where appropriate, but
        i. there must be a clear link between them
        ii. the RQ must be answerable in the 3 000 word limit
    c. IV range must be realistic (e.g., ocean temperatures above 33 ^{0}C are not found)
    d. RQ does not need to be a question, but must be clear what is being investigated

7. Hypothesis is not needed, but may help formulate the relationship between variables investigated
    a. Null and alternative hypothesis only for statistical analysis.
    b. Must be addressed in section E. Analysis & Conclusion
    c. Required even if using statistical programs for calculations

B. Strategy

8. The identified strategy is some intervention designed to address the environmental topic / issue. It can be based in the local context of the study itself or more be more broad in scope, depending on the nature of the issue
    a. Local strategies might be references to photographs, pamphlets, posters or brochures.

b. Could be a community action (e.g., replant trees to address RQ on global deforestation)
c. May be different to investigation, but must clearly and credibly link to the RQ
d. Generalized arguments about the benefits and problems with a strategy that are common knowledge, but with no supporting references, will not score well.

9. Each of the two worldviews / perspectives could be based on (but not limited to) ethics, logic, religion, politics, sociocultural perspectives, economics or pragmatism.
    a. Perspectives chosen must illustrate a stance on the strategy so tensions can be discussed (e.g., the introduction of "meat-free Mondays" in the school canteen by the school, and students resenting the imposition put upon them by the removal of choice).
    b. Discuss the reasons for and against the strategy from each worldview / perspective, with each being linked to the outcome of the strategy.
    c. A conclusion based upon your personal engagement, with an appraisal of the impacts upon the strategy from the divergent worldviews / perspectives.

C. Method

10. The study may be science- or social science-based depending on the nature of the RQ. The 10-hour time may include the method's design, piloting, and redesign if the method is unable to work.
    a. Fieldwork - discuss initial scoping of site(s) along with use of sampling technique (random, stratified, systematic) used.
    b. Laboratory work – ranges of IV that exist in the real world (e.g., rainwater pH 4.0 → 6.0) along with appropriate time constraints (e.g., plant growth, seed germination) are planned.
    c. Surveys - a copy of the survey should be included and referenced in the Appendix

11. Data collected can be from primary or secondary sources and be qualitative or quantitative in nature, and generally consists of five trials at five different IV treatments (5 x 5) as the absolute minimum, with many statistical calculations requiring 30 data points per variable.
    a. Fieldwork - transect studies may prove difficult to collect enough data individually, therefore group work may be more appropriate. Classwide data sets, with different DVs being collected, may also generate enough trials for analysis.
    b. Laboratory work - when digital technology is used (e.g., Vernier™ probes) sampling rate should be considered to gather meaningful, but not excessive, data. This is best determined during pilot trials.
    c. Surveys - enough participants take part to generate meaningful data. Usually this is 30 responders per group required (e.g., 30 male students and 30 female students)

12. The method should ensure the data is as reliable and realistically possible to collect in the time period, and described exactly with no assumptions made so someone unfamiliar can replicate the investigation.
    a. All equipment needed to conduct the investigation should be listed, with quantities (e.g., 500 mL distilled water), sizes (0.25 m^2 quadrat), and brand of manufacturers (e.g., Vernier™) when applicable. Photographs of equipment are not needed unless obscure tooling is used, and include the uncertainty (often labeled D = ± __) with appropriate units.
    b. Fieldwork - standard protocols should be used and cited, but not copied verbatim. Annotated photographs, maps, sampling lengths, and seasons are just some of the features that may be needed here to provide enough details of the investigation.

c. Laboratory work - procedures should be step-by-step, either in numbered bullets or as a paragraph, recording what was done. An annotated picture (drawn or photographed) of the setup is recommended.
d. Surveys - a copy of the survey should be included and referenced in the Appendix. Anonymity is of paramount importance, and permission is required when personal details are required.

13. It is not necessary for variables to be separately stated in a subsection or table, though this format may benefit some investigations such as those done in the laboratory. Some of the information below may be contained in section A. Research & Inquiry.
    a. For the IV include the following:
        i. At least five treatments or levels with the chosen range justified (possibly in Background Research)
        ii. Described exactly with no assumptions, so someone unfamiliar can replicate
    b. For the DV include the following
        i. Justification explaining why this was chosen (possibly in Background Research)
        ii. Any calculation(s) needed to obtain a derived DV
        iii. Described exactly with no assumptions, so someone unfamiliar can replicate
    c. CVs should be measurable variables, not things like “same meter stick”. A table may be best
        i. Each variable is justified as relevant to why they are controlled
        ii. Explained how they were controlled
        iii. The actual values are stated (if possible)
    d. Uncontrolled variables should be stated, with best practice to avoid their effect on the data.
        i. These include weather, time of day or season, genetic differences, variation in different locations or substrates, and many others.
        ii. These variances are random errors, and care to both eliminate their impact(s) and disclose their effect(s) should be explained in F. Evaluation.

14. Risk and ethical assessment is no longer assessed, but all investigations **must** follow IB sciences experimentation guidelines and Ethical guidelines for extended essays research and fieldwork. Failure to follow these may jeopardize the entire cohort’s IA and may trigger IB contact with the school.
    a. Samples stored for any length of time may change measurable parameters. This time period should be disclosed, and care taken to make these impacts as small as reasonable.
    b. Samples, and especially living organisms, should be ethically collected and returned as soon as possible, with destructive methods (e.g., biomass) avoided if possible.

D. Treatment of Data

15. Data tables are numbered and titled, clear and consistent.
    a. Raw data and processed data are easily differentiated
    b. Decimal places and significant figures in a column must all be the same
    c. Don’t bridge page breaks (long data tables in Appendix), otherwise re-label column headers

16. Include detailing of how you got the data value
17. Information is detailed (not general) and taken from your notes and observations are relevant to the collection of the quantitative data.
    a. The length of this section may vary greatly pending on the methodology

18. Processing is detailed and sample calculations are of complex computations
    a. The report should use correct and relevant scientific notation, equations and units.

b. The results of addition and/or subtraction should be rounded off so it has the same number of decimal places (to the right of the decimal point) as the uncertainty - with units.
c. Some mention of the reliability of the data (chi-squared test, standard deviation, correlation, etc.)

19. All graphs are
    a. computer generated, colored appropriately and large enough to read all text.
    b. Representation directed by the theory and hypothesis (i.e., if theory says $I = \frac{k}{x^2}$, *then plot* I *vs* $\frac{1}{x^2}$)

20. Stated in detail and based on the original research question. Includes the result of data analysis with units. Apply null hypothesis if needed.

21. Provide justification for the result(s) of the investigation based on your environmental issue
    a. When there is a known scientific context or accepted value, then compare their result with the accepted value.
    b. When there is no such known scientific context or accepted value then a reasonable interpretation of the accepted scientific context should be given.

E. Analysis & Conclusion

22. Evaluation a strength and weaknesses analysis of
    a. The precision of the quality and range of data is included.
    b. The design of the investigation
    c. An appreciation for any assumptions in your methodology.

23. Improvements and extensions are realistic and relevant
    a. The improvements need to be specific and based on the evaluation and appreciation of the weaknesses and limitations.
        i. Analyze each variable (IV, DV & control variables) and how it was measured/controlled, searching for areas that could be improved.
        ii. Possibly use a table to organize your Variables & Evaluation together.

Variable	Issue	Solution
IV		
DV		
CV's		

    b. Significant improvements or further research can be an extension to better understanding of your environmental issue.

24. Provide an application or solution to the environmental issue above
    a. Base it on your research and findings of the investigation.
    b. Evaluate the feasibility, strengths, weaknesses and any limitations to your proposed plan or solution.

Communication points to consider

1. Report stayed focused on the research question and related the environmental issue all the way through to Application.
2. The report did not ramble on with generalities about interest(s), historical background or unnecessary pedantic details.
3. Check that your print layout makes it ***easier*** to read your report and flows naturally
    a. Especially at tables, images, graphs/charts, paragraph beginnings and ends.
    b. Test this by exporting it as a PDF, (FINAL DRAFT will be submitted electronically as a .pdf file)